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Current Approach to Coronary Bifurcation Lesions

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Abstract

Coronary bifurcation lesions constitute an important part of interventional cardiology. Advances in the field of interventional cardiology and the patient's comorbid condition have significantly reduced the number of patients undergoing surgical intervention. Recently, interest in DK-crush and nano-crush stenting has led to a significant increase in the number of bifurcation attempts. In this article, we presented the current approach to coronary bifurcation lesions that will be beneficial for interventional cardiologists.

Keywords: ınterventional cardiology; coronary bifurcation; stenting techniques.

Introduction:

prostatic hyperplasia is a non-malignant hyperplasia of prostatic tissue which Bifurcation lesion is a stenosis that holds the origin of an important side branch (proximal first 3mm) [1]. It constitutes 15-20% of all coronary interventions. It is one of the most difficult lesions of interventional cardiology [1]. These lesions significantly affect the success of the procedure. Recent comparative studies have played an important role in determining the stent technique to be applied to these lesions. Various parameters such as clinical, electrocardiographic findings, level of cardiac biomarkers, diameter of the side branch and bifurcation angle are important in making the decision to intervene in these lesions. Bifurcation lesion is a coronary lesion that increases the risk of morbidity and mortality [3]. Therefore, we presented the current approach to coronary bifurcation lesion.

Definition and Classification

While true bifurcation lesion refers to lesions with >50% stenosis, including the main branch and the lateral branch, pseudo-bifurcation lesion refers to only one of the severe stenosis in the main branch or lateral branch at the bifurcation level [4]. Murray's law or Finet's formula is used to estimate the proximal branch diameter at the bifurcation level [5].

In Murray's law; Proximal branch diameter^3:Distal branch diameter^3 + Side branch diameter^3.

In the Finet formula; Proximal branch diameter: (Distal branch diameter + Side branch diameter)x0.678.

Although there are many classifications in the literature to define bifurcation lesions, Medina's classification is frequently used. In the Medina classification, it is expressed as 0 if there is no stenosis of 50% or more, and 1 if there is [6]. Classification is made according to proximal branch, distal branch and side branch severity, respectively. For example, if there is 70% stenosis in the proximal branch, 60% stenosis in the distal branch and 40% stenosis in the lateral branch, this bifurcation lesion is expressed as 1.1.0. In bifurcation lesions, a 6F guiding catheter can be intervened with a radial approach. A 7F guiding catheter is required in patients with simultaneous use of 2 stents or 3 balloons or in whom rotational atheroctomy is planned (burr size >1.75 mm) [5]. Wiring of the side branch is recommended for lesions in which an important side branch emerges. When the stent is placed in the main branch, the jailed wire increases the angle between the main branch and the lateral branch, preventing the occlusion of the lateral branch connected to the plate shift. It also guides us when the side branch is blocked.

Hydrophilic jailed wire can be easily retracted like non-hydrophilic wires [7,9].

Intervention Indications

Approach to non-main coronary bifurcation lesions

If there is no severe stenosis in the main branch and side branch (if it is not a true bifurcation lesion), the provisional side branch stenting should be considered. In provisional side branch stenting, a stent is placed in the main branch. If it is a true bifurcation lesion, the intervention technique is determined according to the characteristics of the side branch and the side branch lesion. In this case, if the side branch diameter is 2.5 mm or more, and the lesion extending distally from the side branch ostium is 10-20 mm, elective intervention can be performed with the crush or mini-crush technique [10].

In some sources in the literature, 2 stent techniques are recommended for lesions extending 5 mm distal from the side branch ostium with a side branch diameter of more than 2.5 mm. The preferred approach in bifurcation lesions is provisional side branch stenting with proximal optimization therapy.

The T stent technique can be used if there is > 75% residual lesion in the side branch after provisional stenting, if dissection is developed, if flow is reduced or if there are signs of ischemia, if it can be entered through the distal strut. If it can be entered through the proximal strut, TAP or culotte stent technique can be used. If there are 75% or less lesions after provisional stenting, if there is no dissection, if the flow is normal, if there is no sign of ischemia, POT-Side-POT can be performed or left as such. In POT-side-POT procedure, firstly, in provisional stenting, POT procedure is performed on the main branch, followed by balloon dilation to the side branch. Finally, the final POT is made to the main branch. If FFR has been performed and a severe hemodynamic lesion is detected, T stent (if it can be inserted through the distal strut), TAP or culotte stenting (if it can be entered through the proximal strut) can be performed. In all bifurcation attempts, a final kissing balloon is applied. In complex 1,1,1 lesions (side branch lesions where side branch access is difficult and / or occlusion risk is high), culotte stenting (first side branch stenting with mandatory POT), systematic T stenting, double kissing crush stenting with minimal main branch protrusion (POT and final kissing balloon application after main branch stenting) can be done [11].

Approach to main coronary bifurcation lesions

Side branch lesion length and severity are important in determining the intervention technique in the intervention of the main coronary bifurcation lesions. If the severity of the side branch lesion is <70% and / or the lesion length is <10 mm, it is considered as a simple lesion. After this stage, minor branch accessibility is evaluated. If the side branch is easily accessible, a provisional or inverted provisional technique can be used according to the consensus of the European Bifurcation club. In this case, it is approached with a single stent technique. After the single stent technique, the side branch is evaluated. If the flow in the side branch is reduced or the FFR is 0.8 and below, two stent techniques such as T / TAP / culotte stenting are used. If the side branch is not easily accessible, inverted panty stenting is chosen where the first stent is placed in the side branch. In the main coronary lesion, if the severity of the side branch lesion is 70% or more and / or the lesion length is over 10 mm, it is called a complex lesion. In this case, according to the Asian Bifurcation ash consensus, the double kissing crush technique, in which the first side branch stenting is performed, is used. IVUS / OCT is strongly recommended after primary coronary stenting [11].

Classification of Bifurcation Stenting Techniques

MADS-2 (Main prox. first, Main Across side first, Double prox. lumen, Side branch first) classification is important in terms of showing bifurcation stenting techniques [10].

According to the MADS-2 classification, balloon dilatation can be performed by placing a stent proximally to the main branch. Subsequently, stents can be implanted in branches distal to the main branch. In addition, in another approach of this classification, a stent can be placed in the main branch to cross the side branch, which is a provisional approach. In the provisional approach, the main branch is POT, and the balloon dilatation is made to the side branch. Subsequently, the process is terminated with kissing balloon dilatation. T stenting, TAP stenting, Culotte stenting techniques can be used in this step when we need to place a stent in the side branch. In another approach according to the MADS-2 classification, a stent can be applied to create a double lumen in the proximal branch, and these stenting techniques are V stenting or SKS stenting. According to this classification, as another approach, a stent can be placed in the side branch first. In this approach, intentional T stenting or double kissing crush stenting can be used as stenting techniques [10,16].

In inverted approaches, on the other hand, there is an inverted provisional approach where the distal main branch is crossed with a stent first, or the approach where the distal main branch is stented first. In the techniques where we extend the stent from the side branch to the main branch, after POT and kissing balloon dilatation, two stent strategies can be used, if necessary, inverted T, inverted TAP, inverted culotte stenting technique. Special stents TRYTON can be used in these stenting techniques. When we need to place a stent in the distal main branch first, we can crush the distal main branch stent with a balloon and extend the stent from the side branch to the main branch, which is double kissing crush stenting. In addition, the inverted intentional T stenting technique can also be used to stent the distal main branch first [10,11,17-19].

Bifurcation Stenting Techniques

Provisional Stenting

The drug-coated stent is implanted into the main branch, crossing the side branch, 1: 1 according to the distal vessel diameter. Even if there is no major disease, the stent should be long. In order to perform proximal optimization treatment in the proximal main branch, it is important that the noncompliant balloon is too short to reach the carina level (usually 8 mm). Subsequently, proximal optimization treatment is performed. For this procedure, dilatation is performed with a semi-compliant or non-compliant balloon, 1: 1 according to the proximal main vessel diameter. However, noncompliant is chosen in stent underexpension or when proximal main vessel diameter is not evident. Semi-compliant balloons, on the other hand, can provide appropriate displacement of stent struts containing vascular wall apposition in the absence of the

disease. In the provisional approach, whenever a side branch is required, distal rewiring is performed using the pullback technique and the side branch is wired. Subsequently, the main branch balloon is selected to be 1: 1 according to the main distal branch diameter, while the side branch balloon is selected to be 1: 1 according to the side branch diameter. Short non-compliant balloons are used in kissing balloon dilatation. Main branch and side branch balloons are inflated and deflated at the same time. Or first the main branch and then the side branch balloon is inflated and deflated. Subsequently, the proximal main branch is re-POT made above the level of the carina, 1: 1 according to the proximal main branch diameter. In inverted provisional stenting, the stent is extended to the proximal main branch to cross the side branch of the distal main branch. Other steps are similar to provisional stenting [10,11].

T/TAP Stenting

This stenting technique is suitable when the bifurcation angle is 90 degrees. At angles below 90 degrees, there may be an area without a stent in the ostium of the side branch. In this case, the risk of restenosis increases in the side branch ostium. Or, access to the distal main branch may be difficult due to the withdrawal of the stent into the main branch. In this stenting technique, a 1: 1 balloon is placed in the main branch in accordance with the diameter of the distal main branch. In T stenting, the stent is first placed in the main branch, while in the modified T stenting TAP stenting, the stent is first placed in the side branch. In these stenting procedures, while the balloon is inflated in the main branch, a stent is implanted in the side branch. Subsequently, the stent balloon on the side branch is retracted and re-inflated. Thus, optimal opening is provided in the ostium of the side branch. Then, kissing balloon dilatation is performed by simultaneously inflating the main branch and side branch balloons. In some standard tests, sequential high pressure balloon dilatation is recommended as an alternative to non-compliant balloons. However, balloon inflation and deflation should be performed simultaneously for a central neocarina to form. Following these procedures, the proximal optimization treatment is repeated. So re-POT is done. In this procedure, the distal of the re-POT balloon should not reach the neocarina. Otherwise, the central position of the neocarina is shifted [10,11].

Culotte Stenting

In this bifurcation stenting procedure, firstly the lesions should be prepared for stenting. For this, both branches are predilated. Subsequently, the side branch is stented first. Stent diameter is determined by the diameter of the distal side branch. Its length, on the other hand, should be such that the POT procedure is performed in the main branch. Subsequently, post-dilatation is performed to the proximal of the side branch stent with a balloon determined according to the proximal main branch diameter, from the top of the neocarina. The diameter of the balloon used for this procedure should be 1: 1, determined by the diameter of the proximal main vein. Then, we should pull the wire on the side branch and wire the main branch so that it passes near the carina. After the distal main branch is covered, balloon dilatation is performed to expand the mouth of the stent carina. Kissing balloon dilation can also be done for this procedure. Subsequently, the stent is implanted in a way that extends to the proximal main branch, 1: 1 for the distal main branch diameter. Subsequently, a re-POT procedure is performed in the proximal main branch in such a way that it does not reach the carina. In this procedure, a 1: 1 balloon dilatation is performed according to the proximal main branch. Then, distal rewiring is done into the side branch with the pull-back technique. Then, kissing balloon dilatation is performed using short non-compliant balloons. After two balloons are placed in the appropriate position, after successive high pressure balloon dilatation, simultaneous kissing balloon dilatation is performed. Subsequently, the final POT procedure is performed over the carina, 1: 1 according to the proximal main branch diameter. In the mini culotte technique, the stent placed in the side branch is placed in a way that it extends minimally to the main branch (facing the opposite wall in the main branch). In this procedure, rewiring should be done from the most distal strut. If dissection has developed in the side branch after predilatation in patients for whom we decided to use the Culotte stent technique, DK-crush or nano-crush stenting can be switched to. If possible, an undersized balloon should be chosen to prevent dissection during predilation in patients for whom the Culotte stent technique is chosen [10,11].

DK-Crush Stenting

In this stenting technique, predilation is applied to both branches first. Subsequently, a stent is implanted 1: 1 according to the diameter of the distal side branch, covering the side branch disease. The side branch stent should be placed into the main branch with a protrusion of 2-3 mm. A balloon is placed inside the main branch at the carina level. After the side branch stent is inflated, this balloon is withdrawn and re-inflated at high pressure. Meanwhile, the balloon within the main branch is simultaneously inflated. This stage is called side branch optimization. Thus, optimal opening of the side branch ostium is achieved. Subsequently, the balloon of the side branch and the guidewire are removed. Then, the protruding side branch stent is crushed with the appropriate balloon according to the amount of atherosclerosis and the diameter of the main branch. In some standard tests, an optimal crush process is applied with the proximal optimization technique. Subsequently, the side branch wiring is performed to pass through the non-distal cell. Subsequently, consecutive balloon dilatation is performed with two balloons, 1: 1 according to the diameter of the distal main vessel and distal side branch. Alternatively, simulated kissing balloon dilatation can be performed, followed by removal of balloons and side branch guidewire. Subsequently, a stent is implanted so that it is extended to the proximal main branch. Subsequently, the re-POT process is performed. Then, rewiring is performed from the non-distal cell in the side branch ostium. Subsequently, simulated kissing balloon dilatation is recommended according to the sequential technique. This is done with high-pressure non-compliant balloons. Subsequently, the final POT is performed above the carina level [10,11,20,21].

Nano Crush Stenting

In this technique, both bifurcation branches are wired first. After the branches are tied, predilatation is performed with simultaneous or consecutive noncompliant balloons.

Subsequently, a stent is placed in the side branch. Subsequently, while the non-compliant main branch balloon is inflated at nominal pressure, the side branch stent is pulled into the main branch to create indentation in the balloon of the main branch. In this step, the balloon used in the main branch should be less than the diameter of the distal main branch. For example, a 2.5 mm noncompliant balloon can be selected for a 3.5 mm main branch. In this case, the indentation side branch stent is implanted while the main branch balloon is inflated. After the side branch stent is placed, the stent balloon is inflated to 20 atm, with half of the balloon in the main branch and half in the side branch stent. In the main branch, the side branch stent is crushed with a noncompliant balloon at a high pressure of 20 atm. After the side branch stent is crushed with the balloon of the main branch, the first kissing balloon dilatation is performed. Thus, an important opening is provided in the mouth of the side branch and provides easy advancement of the main branch stent. Subsequently, after the first final kissing, the side branch wire and balloon are removed. A stent is implanted in the main branch at a ratio of 1: 1 in accordance with the distal main branch diameter. Subsequently, proximal optimization treatment is performed with a noncompliant balloon in accordance with the diameter of the main branch. Then the side branch is wired. In this process, if possible, proximal or midstruttan rewiring is done. Subsequently, the final kissing balloon dilatation is performed. Finally, the process is terminated with the final re-POT [22,23].

Bioresorbable Stents in Bifurcation Stenting

First, the main branch and the side branch are wired. The lesion is prepared by predilation with a balloon at a ratio of 1: 1 in accordance with the diameter of the main branch. Keeping in mind the limited expansion of the stent, the appropriate stent diameter is determined according to the distal main branch diameter. The bioresorbable stent is opened slowly as recommended by the manufacturer. POT is made for the proximal part of the main branch stent. The maximal stent expansion is 3.7 mm for a 3 mm bioresorbable stent and 4.2 mm for a 3.5 mm bioresorbable stent. If the hemodynamic lesion is not developed in the side branch, the procedure is stopped. When a significant lesion develops in the side branch, the main branch stent struts are opened with a noncompliant balloon. Stent fracture threshold is 10 atm in absorbable bioresorbable stents. Bioresorbale stent distortion can be corrected with POT-side-POT dilatation or mini kissing balloon dilatation. During the kissing balloon dilatation, minimal side branch balloon protrusion and low pressure dilation (5 atm and less) into the main branch are recommended. Conventional kissing balloon dilatation is not recommended due to stent fracture [11].

Comparison of Randomized Bifurcation Studies

In the DC Crush II (Double Kissing Crush versus Provisional Stenting Technique for Treatment of Coronary Bifurcation Lesions) study(24) in which 370 patients were taken, no difference was observed in terms of major cardiac events (cardiac death, myocardial infarction, target vessel revascularization) compared to provisional stenting in 2 stent techniques during 1-year follow-up. However, rates of main branch and side branch restenosis, target vessel revascularization, and lesion revascularization, which were the secondary endpoints, were less common in the DK-crush stenting group.

In the DK Crush V study(25) (Double Kissing and Double Crush Versus Provisional T Stenting Technique for the Treatment of Unpro- tected Distal Left Main True Bifurcation Lesions: A Randomized, International, Multi-Center Clinical Trial), it was found that major cardiac events, target lesion revascularization and stent thrombosis were less in the group with DK-crush stenting in the main coronary compared to the provisional stenting.

In the BBC ONE (British Bifurcation Coronary Study, 2004-2007) study [26] involving 500 patients, patients were divided into provisional T stenting and complex strategy groups (culotte stenting or crush stenting). The patients were followed for 9 months. In this study, an increase in hospitalization time and major cardiovascular events was observed with the 2 stent technique. This difference was due to periprocedural myocardial infarction. In the 2 stent technique, while the procedure time was long, the X-ray dose was higher.

In the CACTUS (Application of the Crushing Technique Using Sirolimus-Eluting Stents, 2009) study [27] 350 patients were followed for 6 months. In this study, crush stenting was compared with provisional T stenting. In this study, no significant difference was found between the two groups in terms of major cardiac events, stent thrombosis, and instent re-stenosis. However, 31% of the provisional T stenting group required a second stent to be placed.

In the BBK-1 (Bifurcations Bad Krozingen 1, 2008) study [28] involving 202 patients, the provisional T stenting was compared with the routine T stenting technique. In this study, no difference was found between the two techniques.

In the BBK II (Culotte Stenting Superior to TAP in Treating Coronary Bifurcations, 2016) study involving 300 patients, TAP stenting and culotte stenting were compared. In this study, angiographic restenosis rates were found to be lower in culotte stenting compared to TAP stenting. At 1-year follow-up, there was no difference between the groups in terms of death, target vessel revascularization and stent thrombosis.

The study of BBK-3 (Culotte Versus DK-CRUSH Technique in Non-left Main Coronary Bifurcation Lesions, 2019-2021 years) continues.

In the DEFINITION-2 study(30), in which 653 patients were enrolled, patients were followed for 1 year. Cardiac death, myocardial infarction, and revascularization were determined as the primary endpoint in this study. In this study, two stent techniques were compared with provisional stenting. In this study, a significant decrease in the primary endpoints was found in the 2 stent techniques compared to the provisional stenting. DK-crush stenting has often been performed in the 2 stent technique.

In the NORDIC-1 study [31] (2004-2005) in which 413 patients were enrolled, provisional Tstenting and complex stenting (crush, culotte, T stenting, and others) were compared. In this study, there was no difference between the groups in terms of major cardiac events at the 6-month clinical follow-up, while the 5-year mortality rate was found to be lower with the provisional T stenting at the 5-year follow-up compared to the complex stenting.

In the Nordic-Baltic bifurcation study IV [32] (randomized comparison of provisional side branch stenting versus a two-stent strategy for treatment of true coronary bifurcation lesions

involving a large side branch), a simple provisional strategy was compared with two complex stent strategies. In this study, no difference was found between the two groups in terms of outcomes such as all-cause mortality, cardiovascular mortality, myocardial infarction, and target lesion revascularization. However, angiographic side branch stenosis was found to be less in the group in which two stent strategies were applied with high fluoroscopy time, procedure time and contrast volume.

The EBC TWO (European Bifurcation Coronary TWO; between 2011-2014) study [33] involving 200 patients compared the provisional T stenting and 2 stent culotte strategies in true bifurcation lesions with long side branch stenosis. In this study, no difference was found in terms of death, myocardial infarction and target vessel revascularization at 1-year follow-up.

In a single-center non-randomized study by Rigatelli et al. [22] comparing nano crush stenting and culotte stenting in the main coronary lesions, less contrast volume, less procedure time and less X-ray exposure were found in the nano crush stenting group at 3-year follow-up.

If we briefly evaluate the main coronary bifurcation stenting studies, we can state the following [25,29,34]:

1. According to the results of the DK crush 3 study, which was concluded in 2015, the DK crush culotte is better than stenting.
2. According to the results of the BBK 2 study concluded in 2016, culotte stenting is better than TAP stenting.
3. According to the results of the DC crush 5 study, which was concluded in 2017, in complex lesions, DC crush is better than provisional stenting.

Coclusions

Bifurcation stenting, which constitutes an important part of interventional cardiology, is developing day by day in terms of the number of technical approaches and technical content. Especially in recent years, interest in DK-crush stenting and nano-crush stenting techniques has increased. However, the number of studies comparing nano-crush stenting with other techniques is insufficient. DK-crush stenting, on the other hand, has proven its effectiveness in certain studies and seems to be the currently accepted technique. TAP stenting and culotte stenting come to the fore in cases where we need to switch from provisional stenting to double stenting strategy. We can say that it is the technique that the best technical operator knows best in terms of knowledge and skills.

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